Fragm. Agron. 34(3) 2017, 76–87

THE EFFECT OF TWO DIVERSE GROUP OF CROPPING SEQUENCES IN A PRODUCTION FARM ON POTASSIUM MANAGEMENT

Remigiusz Łukowiak[1], Witold Grzebisz, Przemysław Barłóg, Jarosław Potarzycki, Karol Kotnis

Department of Agricultural Chemistry and Environmental Biogeochemistry, University of Life Sciences, Wojska Polskiego71F, 60-625 Poznań

Abstract. The main objective studies conducted in 2004–2007 in a production farm Górzno, Poland, was the evaluation of crop grown in 15 cropping sequences (CSs) with oilseed rape (OSR, 9) or maize (6) on potassium (K) management. The K balance components were: i) content of $CaCl_2$ extractable K in soil layer of 0–0.9 m prior to spring growth and after harvest, ii) K input from applied mineral fertilizers, iii) K total input (fertilizer, farmyard manure, rainfall, seeds), iv) K output (main products, crop residues). The Unit Potassium productivity (UKP) was determined individually for of the main K source. The K balance was conducted using two methods: the Soil Surface balance (SSuB), and the Soil System Balance (SSyB), taking into account the quantity of soil K. Indices of UKP, irrespectively of K sources, revealed as a useful diagnostic tool for the CS discrimination. The negative values of indices such as the TKB and TGKB indicate the significant contribution of soil K resources in covering requirements of grown crops. Yields of crops cultivated in both cropping sequences depended significantly on soil ready for use K resources. Maize, especially grown for silage, caused a stronger exhaustion of soil K available pool, compared to sequences with oilseed rape as a dominant crop.

Key words: oilseed rape, maize, methods of budgeting, K balance indices

INTRODUCTION

A sustainable exploitation of crop productivity is a result of effective management of nutrients responsible for nitrogen uptake, water use and its resistance to pathogens. It seems obvious that an adequate supply of K to plants is in line to meet these challenges [Grzebisz et al. 2013, Zlámalová et al. 2015]. In the real agriculture practice of the Central Europe dominates a negative potassium balance. Therefore, yields are year-to-year variable, depending mainly on the impact of environmental factors [Grzebisz and Diatta 2012, Madaras et al. 2014].

The current status of K depletion can be assessed based on soil and/or plant tests. Grzebisz and Oertli [1993], using winter rye as a quick plant test, implicitly indicated on the non-exchangeable K as the key its source in K depleted soils. The same conclusion was reached by Madaras and Koubová [2015] testing K content in depleted soil in the Czech Republic. Crop production, basing on negative K balance, forces plants to use non-exchangeable K pool. However, this strategy of K management results in yield decrease [Rutkowska et al. 2014].

The key disadvantage of the standard soil tests for potassium is its limitation to the topsoil. Currently, it is more frequently assumed that the entire deep-rooted zone should be considered as an important source of nutrients, including potassium [Struik and Bonciarelli 1997]. A 0.01 M $CaCl_2$ solution is recognized as the useful chemical agent for determining both inorganic N

[1] *Corresponding address* – Adres do korespondencji: lukowiak@au.poznan.pl

and potassium content in arable soils [Houba et al. 2000]. It would be rational, following the standard procedure for mineral N, to receive simultaneously data on the content of other nutrients such as potassium in the entire rooted soil volume.

The Soil Surface Balance (SSuB) as a tool for K budgeting requires both recorded data, such as rates of applied fertilizers and yields of crops, and estimated data, such as the amount of K in rainfall. Its disadvantage is lacked of data on K in byproducts. The Soil System Balance (SSyB) requires also data on internal K sources such as its easily available soil pool [Cherry et al. 2008].

The minor objective of the study was to evaluate potassium management in two groups of cropping systems dominated by oilseed seed rape or maize. The major objective was to assess the importance of the subsurface soil layers in K supply to crops.

MATERIAL AND METHODS

This study was carried out at the Górzno farm during the 2004–2007 growing seasons, located in central-western Poland (51°74′ N, 17°83′ E). The farm has 400 ha of agricultural land, dominated by arable soils classified as typical Luvisols. The acronyms presented in Table 1 indicate the intensity of the cropping sequence, as related with the frequency of oilseed rape (9 fields) and/or maize (6 fields) cultivation. Yield of cereals and oilseed rape was measured with

Table 1. Field characteristics and cropping sequence of fields at the Górzno Farm

Field	Field acronym	Field size ha	Soil texture[1]	Cropping sequence (CS), seasons 2004–2008
1	OR1	14.8	LS	WW[2] -**WR-WR-OR-**WW
2	OR2	7.0	SL	OR-**WW-WR-OR-**WW
3	OR3	17.2	S	OR-**WW-OR-WW-**OR
4	OR4	15.5	S	OR-**WW-OR-WW-**OR
5	OR5	13.7	S/LS	OR-**WW-OR-WW-**OR
6	OR6	10.3	S	OR-**WW-OR-WW-**OR
7	OR7	9.5	S	OR-**WW-OR-WW-**OR
8	OR8	40.8	LS	OR-**WW-OR-WW-**OR
9	OR9	46.6	SL	OR-**OR-WW-OR-**WW
10	SM1[s]	55.0	LS	ON-**WR[f]-SB-SM[f]-**WW
11	SM2	13.4	LS	SM-**SM-WW-OR-**WW
12	SM3	14.9	LS	SM-**SM-WW-OR-**WW
13	SM4[s]	14.8	LS	SM-**SM-SM-SB-**SM
14	SM5[s]	26.2	LS	SM-**SM-SM[f]-SM[f]-**SM
15	SM6[s]	31.6	S/LS	SM-**SM-SM-SM[f]-**SM

[1]soil testure: S – sand, LS – loamy sand, SL – sandy loam; [2]OR – winter oilseed rape,
SM – silage[s]/grain maize, WW – winter wheat, WR – winter rye, SB – spring barley,
f – farmyard manure applied. The years of full study are indicated in bold

a combine harvester and maize by silage harvester. To facilitate comparison, yields of all crops were converted into Cereals' Units CUs, [Brankatschk and Finkbeiner 2014].

The composite soil samples were collected from each field twice a year, at the beginning of each spring season for winter crops and prior to planting the spring crops (acronym: Spring – S) and immediately after harvest and prior to planting the winter crops (Autumn – A). The one sample represents an area of 4.0 ha, and the total number of samples was adjusted to field size. They were taken at three depths: 0.0–0.3, 0.3–0.6, and 0.6–0.9 m. The soil available potassium (K_{sav}) was determined in 0.01 M $CaCl_2$ solution for a soil ratio of 5:1 [Houba et al. 2000].

The plant samples for K content were taken at harvest from a particular plot from an area of 1.0 m^2. The dried plant material (65^o C) was incinerated in a muffle furnace at 550°C and the obtained ash was dissolved, using 33% HNO_3. Potassium concentration was measured by AAS (SpectrAA 250 Plus, Varian). Potassium content was calculated based on its concentration and biomass of a particular crop part.

Components of potassium budget include (kg $K \cdot ha^{-1}$):

1) Input (K_I): K fertilizer (K_f), farmyard manure (K_{fym}), seeds (K_{se}), precipitation (K_{prec});
2) Output (K_O):
   a. yield (K_Y): grain (cereals, maize), seeds (oilseed rape), whole biomass (silage maize),
   b. crop residues (K_{res}): straw, harvest residues;
3) Soil available K (K_{sav}), measured:
   a. before the spring season for a particular crop start – ($K_{sav\text{-}S}$, kg $K \cdot ha^{-1}$),
   b. immediately after a particular crop harvest – ($K_{sav\text{-}A}$, kg $K \cdot ha^{-1}$).

Indicators of potassium balance are presented as a series of equations (Table 2). They were calculated based on the composite components of K budget:

$$K_I = \sum(K_f + K_{fym} + K_{se} + K_{prec}), \quad (1)$$

$$K_O = \sum(K_Y + K_{res}), \quad (2)$$

$$K_{TI} = \sum(K_{sav\text{-}S} + K_I), \quad (3)$$

$$K_{TO} = \sum(K_{sav\text{-}A} + K_O) \quad (4)$$

Table 2. Indicators of potassium balance for Soil Surface Balance and Soil System Balance

Indicator	Equation	Dimension
Soil Surface Balance – SsuB		
Net fertilizer Potassium Balance	$NK_fB = K_f - K_Y$	kg $K \cdot ha^{-1}$
Net fertilizer Potassium Efficiency	$NK_fE = (K_y/K_f) \cdot 100$	%
Net Potassium Balance	$NKB = K_I - K_Y$	kg $K \cdot ha^{-1}$
Net Potassium Efficiency	$NKE = (K_Y/K_I) \cdot 100$	%
Total Potassium Balance	$TKB = K_I - K_O$	kg $K \cdot ha^{-1}$
Total Potassium Efficiency	$TKE = (K_O/K_I) \cdot 100$	%
Soil System Balance – SSyB		
Total Net Potassium Balance	$TNKB = K_{TI} - K_Y$	kg $K \cdot ha^{-1}$
Total Net Potassium Efficiency	$TNKE = (K_{TI}/K_Y) \cdot 100$	%
Total Gross Potassium Balance	$TGKB = K_{TI} - K_{TO}$	kg $K \cdot ha^{-1}$
Total Gross Potassium Efficiency	$TGKE = (K_{TO}/K_{TI}) \cdot 100$	%

where: K_{TI} and K_{TO} are the total input and output of potassium in the system, composed as a sum of its external and soil pools.

The experimentally obtained data were subjected to the conventional analysis of variance using computer programs STATISTICA 12®. The differences between treatments were evaluated with the Tukey's test. In tables, figures, and equation's F test results (***, **, * indicate significance at the $P < 0.1\%$, 1%, and 5%, respectively), are given.

RESULTS AND DISCUSSION

The average yield, expressed in Cereals Units (CUs), was 5.07 t·ha^{-1} (Table 3). Its variability as indicated by *CV* of 20% was low, showing, however, sensitivity to the type of CS. The average yield for both CSs was at the same level, but its *CV* for the OR-CS reached 15%, whereas for the SM ones doubled (28%). Oilseed rape can be, therefore, considered as a stabilizer of cropping sequence productivity [Christen and Sieling 1995].

The key external source of potassium for crops was K fertilizer. Its input was more stable in OR compared to SM fields. The applied manure decreased K input variability in the SM-CSs. The lowest amount of $CaCl_2$ extractable K of 87 kg K·ha^{-1} was recorded in fields with silage maize. These results implicitly stress the much stronger demand of silage maize for K compared to grain production, which dominated in other fields. The total K input, in spite of variability of its components, was not significantly different between fields. This study corroborates the opinion by Szczepaniak et al. [2014] that potassium is the critical nutrient for maize with respect for realization its yielding potential. Therefore, the content of available K should be at a sufficiently high level in order to avoid depletion of its soil reserves.

The K output components did not vary significantly. The strongest variability between CSs was observed for K in the main product (*CV* = 78%). The highest values of 119 kg K·ha^{-1} were recorded in fields with silage maize. Potassium in harvested byproducts almost doubled its content in the main yield. It can be, therefore, considered as an important source of K for subsequent crop, when left in the field. The recent study by Wei et al. [2015] clearly showed that four year continuous application of straw resulted in the significant increase of the content of available K (10.3–27.3%). On average, the quantity of soil available potassium after harvest ($K_{sav\text{-}A}$) was equal to its amount in crop biomass. Its contribution to the total K pool (K_{TO}) was cropping sequence specific, reaching 57% for OR and 42% for SM fields. These two figures clearly corroborate the hypothesis on much stronger exhaustion of soil potassium by maize compared to other grain crops [Rutkowska et al. 2014].

The Unit Potassium productivity is a simple index of a nutrient productivity evaluation. The UKP-K_f ranged from 53 to 374 kg CUs·kg of applied fertilizer K, showing strong variability in fields with maize. It ranged from 68 to 144 kg CUs·kg K_f in the OR-CSs. The average UKP-K_I index due to manure application to maize was by 23% lower compared to the UKP-K_f. However, its variability (*CV*), was as high as noted for the UKP-K_f. The UKP-T_I indices, based on the total potassium input in the soil-crop system, were several times smaller compared with previous ones. All indices were a useful tool to discriminate the type of cropping sequence (Fig. 1). As a rule the higher variability, as indicated by the lower R^2, was the attribute of SM-CSs. The R^2 coefficients, irrespectively of the type of CS, increased in the order:

$$\text{UKP-}K_f < \text{UKP-}K_I < \text{UKP-}K_{TI} \qquad (5)$$

This type of relationship simply informs that soil potassium was, irrespectively of their sequence, the key source of this nutrient to growing crops, and stabilizer of their productivity.

The Net Potassium fertilizer Balance (NK_fB) was positive for the OR-CS (+37 kg K·ha^{-1})

Table 3. Basic characteristics of potassium balance components during 2005–2007 as affected by different types of cropping sequences

Field	Cropping sequence (CS)	Field size (ha)	Y-CUs	K_f	K_I	K_{sav}-S	K_{TI}	K_Y	K_{res}	K_O	K_{sav-A}	K_{TO}	UKP-K_f	UKP-I	UKP-T_I
			$kg \cdot ha^{-1}$	$kg K \cdot ha^{-1}$									$kg CUs \cdot kg K^{-1}$		
OR1	WR-WR-OR	14.8	5.33 ab	88.7 b	92.7 b	106 ab	199	2.0	105.8	133	159	291	60 a	58 a	27 ab
OR2	WW-WR-OR	7.0	4.16 ab	56.3 ab	60.4 ab	175 b	235	19.7	80.0	100	163	262	94 a	85 a	18 a
OR3	WW-OR-WW	17.2	5.81 ab	54.5 ab	58.6 ab	109 ab	168	23.7	84.0	108	141	249	126 a	114 a	36 ab
OR4	WW-OR-WW	15.5	5.17 ab	65.1 ab	69.2 ab	117 ab	186	23.9	82.5	107	150	256	81 a	76 a	28 ab
OR5	WW-OR-WW	13.7	6.42 ab	52.9 ab	57.0 ab	133 ab	190	32.8	106.0	139	156	295	144 a	131 a	34 ab
OR6	WW-OR-WW	10.3	5.31 ab	49.1 ab	53.2 ab	128 ab	181	23.5	95.2	119	133	252	124 a	113 a	30 b
OR7	WW-OR-WW	9.5	4.13 ab	62.4 ab	66.5 ab	118 ab	184	20.3	70.9	91	163	254	67 a	63 a	23 ab
OR8	WW-OR-WW	40.8	5.05 ab	51.7 ab	55.8 ab	125 ab	181	21.3	91.6	113	107	220	118 a	107 a	29 ab
OR9	OR-WW-OR	46.6	4.38 ab	66.5 ab	70.3 ab	140 ab	211	19.1	87.0	106	162	268	69 a	65 a	21 a
SM1	WR[f]-SB-SM[f]	55.2	5.94 ab	31.3 ab	80.3 ab	110 ab	190	93.6	68.6	162	156	319	223 ab	86 a	32 ab
SM2	SM-WW-OR	13.4	4.72 ab	89.6 b	93.5 b	125 ab	218	25.2	94.6	120	121	241	53 a	51 a	23 ab
SM3	SM-WW-OR	14.9	4.82 ab	70.2 ab	74.1 ab	113 ab	188	70.5	84.1	155	112	267	71 a	67 a	26 ab
SM4	SM-SM-SB	14.8	7.29 b	19.3 a	23.4 a	145 ab	168	78.9	98.1	177	116	293	374 b	309 b	43 b
SM5	SM-SM[f]-SM[f]	26.2	3.13 a	44.6 ab	88.9 b	87 a	176	117.0	40.0	157	95	252	106 a	32 a	17 a
SM6	SM-SM-SM[f]	31.6	4.33 ab	62.1 ab	88.3 b	87 a	176	119.3	60.8	180	98	278	97 a	47 a	24 ab
Mean		22.6	5.07	57.6	69.5	121	191	47.4	83.3	132	135	271	121	94	27
CV. %		67	20	32	28	18	10	78	21	22	19	9	68	70	25

[a]numbers marked with the same letter are not significantly different; [f]farmyard manure

Table 4. Indices of potassium balance in dependence on cropping sequence, mean for years 2004–2007

Field[1]	SSuB						SSyB			
	NK_fB	NK_fE	NKB	NKE	TKB	TKE	TNKB	TNKE	TGKB	TGKE
	$kg \cdot ha^{-1}$	%	$kg \cdot ha^{-1}$	%	$kg \cdot ha^{-1}$	%	$kg \cdot ha^{-1}$	%	$kg \cdot ha^{-1}$	%
OR1	62.0 b	30	66.1	29	-39.7	151 a	172 b	13	-92.8	148
OR2	36.7 b	44	40.8	40	-39.2	194 a	216 b	9	-26.8	111
OR3	30.8 b	52	34.9	47	-49.1	214 a	144 b	15	-81.0	153
OR4	41.2 b	37	45.3	35	-37.3	156 a	162 b	13	-70.5	139
OR5	20.2 b	75	24.3	68	-81.8	272 a	158 b	18	-104.6	156
OR6	25.6 b	54	29.7	49	-65.6	240 a	158 b	13	-70.0	138
OR7	42.1 b	33	46.3	31	-24.6	139 a	164 b	11	-70.2	141
OR8	30.4 b	49	34.5	44	-57.1	236 a	160 b	12	-38.9	124
OR9	47.4 b	30	51.2	29	-35.8	159 a	191 b	9	-57.9	128
SM1	-62.3 a	240	-13.3	94	-81.9	202 a	97 ab	43	-128.2	165
SM2	64.3 b	29	68.3	27	-26.4	129 a	193 b	12	-22.4	119
SM3	-0.3 ab	120	3.6	113	-80.6	220 a	117 ab	39	-79.2	146
SM4	-92.6 a	792	-88.8	500	-153.6	736 b	56 a	65	-124.1	166
SM5	-72.5 a	389	-18.2	121	-58.2	163 a	69 a	64	-65.9	142
SM6	-57.2 a	321	-31.0	135	-91.8	203 a	57 a	67	-102.5	157
Mean	7.7	153	19.6	91	-61.5	228	141	27	-75.7	142
CV. %	678	138	216	131	-54	64	36	83	-42	12

[1]cropping sequence as described in Table 2; [a]numbers marked with the same letter in a particular column are not significantly different

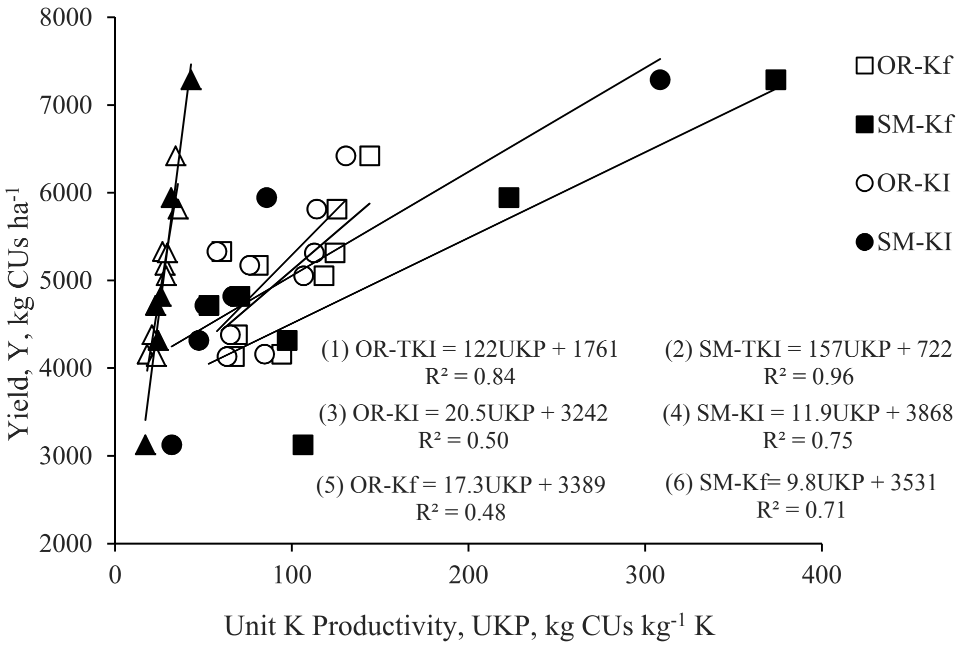


Fig. 1. Relationships between indices of Unit Potassium Productivity and yield

and negative for the SM-CS (-37 kg K·ha^{-1}) (Table 4. The impact of CS on K balance, as shown by *CV*, was moderate in the first OR-CS (32%) and extremely variable in the SM-CS (156%). This index was significantly correlated with the K quantity in the main yield, but only in the SM-CS:

$K_Y = -0.696NK_fB + 69.7$ for n = 6, $R^2 = 0.91$ and $P \leq 0.001$ (6)

The NK_fE in SM fields, except SM2 one, was above 100%, whereas in OR-CSs was at the level of 37%. The NKB and NKE trends were similar to those observed for the NK_fB and NK_fE. The TKB indices were not discriminated by the type of CS. However, the most important message refers to its negative value, averaged to -61.5 kg K·ha^{-1}. It is equal to the amount of potassium taken up by crops from soil resources during the season. It informs that potassium external supply was insufficient to fulfil plant requirements, covering only 47% of the K_O. This conclusion was corroborated by TKE, which varied from 129% (SM2) to 736% (SM4). Both indices stress on soil K resources, as the important source of potassium for grown crops. This conclusion was fully corroborated by indices of TNKB, which were as a rule positive, but CS specific. The TNKB average for the OR-CS was 169 kg K·ha^{-1}, whereas for the SM-CS reached 98 kg K·ha^{-1}. In addition, the *CV* was at the level of 13% and 53%, respectively. It can be concluded that the OR cropping sequence present much stabile K management strategy compared to the SM one. The negative value of TGKB of -75.7 kg K·ha^{-1} informs that this amount of potassium was released during the season from its soil pool, ranging from 22 (SM2) to 124 (SM4) kg K·ha^{-1}. As shown in Figure 2, harvested yields depended linearly on the amount of soil released K, being much stronger in cropping sequences with maize.

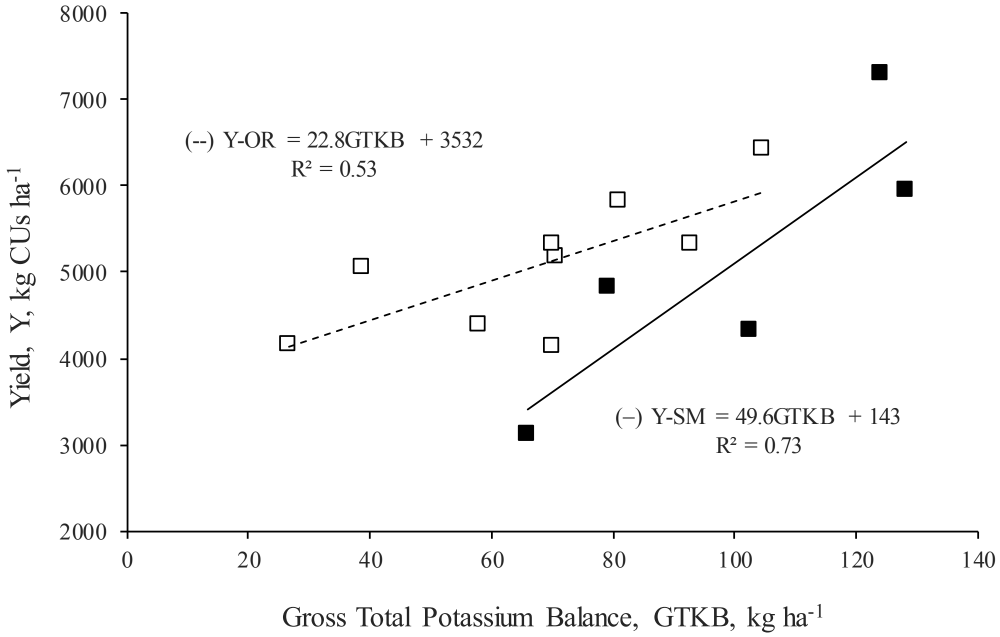


Fig. 2. Yield response to the amount of soil potassium released during the growing season

The year-to-year variability in the content of $CaCl_2$-K, averaged over sampling date and soil layer, was cropping sequence specific (Table 5). Potassium content in five OR and two SM plots was very stable, irrespective of the course of weather. The strongest year-to-year variability was the attribute of the SM4 field, which yielded the highest, in spite of lack of K fertilizer application. The in-season K content variability was significant in 8 of 15 CSs, and its increase during the season was recorded in six of eight fields. The vertical distribution of soil potassium as affected by CS was observed in 3 of 15 fields. The most pronounced impact of all factors on K distribution was observed in the SM1 field (Fig. 3). In 2005, the vertical content of K decreased during the season down to 0.9 m. This trend reflects mainly the effect of manure, which was applied to the first and third crop in this cropping sequence.

The key objective of this study was to evaluate the sensitivity of crops to the amount of easily available K in the vertical soil profile. It was found that plants grown in OR-CSs did not respond to the quantity of potassium in subsequent soil layers. A quite reverse model was found for fields with maize, which yields were affected by the amount of K in the soil layer extended down to 0.6 m (Fig. 4). The observed discrepancy between these two types of cropping sequences, in spite of the same total K output (K_{TO}), indicates on different mode of K uptake by oilseed rape and maize. The first crop due to rhizosphere acidifying is less dependent on K resources within the soil body [Barraclough 1989]. Maize, because of its high requirement for potassium during the vegetative growth develops a very extensive root system in order to explore a big soil volume [Hammer et al. 2009]. It can be concluded that the potassium fertilization strategy in crop rotation with maize cannot be limited to a single application of this nutrient before sowing.

Table 5. Temporal and vertical distribution soil available potassium content in dependence on cropping sequence kg (K·ha^{-1})

Field	Main factors								Significance of interactions			
	Years (Y)			Sampling date (D)		Layers (L)			YxD	YxL	DxL	YxDxL
	2005	2006	2007	S	A	A	B	C				
OR1	63.5 b	35.3 a	33.5 a	35.2 a	53.0 b	46.8	44.1	41.4	*	n.s.	n.s.	n.s.
OR2	60.8 b	72.7 b	35.2 a	58.3	54.2	60.7 b	67.1 b	40.9 a	*	n.s.	**	n.s.
OR3	41.4	44.8	38.7	36.3 a	46.9 b	43.3	45.1	36.5	n.s.	n.s.	n.s.	n.s.
OR4	47.8	36.6	46.8	38.9 a	50.0 b	49.2	44.0	40.0	n.s.	n.s.	n.s.	*
OR5	48.4	53.2	43.1	44.4	52.0	54.4	47.7	42.6	n.s.	n.s.	n.s.	n.s.
OR6	42.8	42.7	45.0	42.7	44.3	44.2	45.6	40.6	*	n.s.	n.s.	n.s.
OR7	46.8	43.0	50.6	39.2 a	54.4 b	45.6	48.4	46.4	n.s.	n.s.	n.s.	n.s.
OR8	37.2	41.6	37.5	41.8 b	35.7 a	42.7 b	38.4 ab	35.1 a	n.s.	n.s.	***	***
OR9	45.3 a	49.4 ab	56.6 b	46.7 a	54.1 b	50.6	53.9	46.8	***	n.s.	n.s.	***
SM1	32.7 a	51.6 b	48.9 b	36.7 a	52.1 b	50.4 b	50.6 b	32.3 a	***	***	**	***
SM2	33.7 a	49.9 b	39.0 ab	41.5	40.2	41.8	44.5	36.3	**	n.s.	n.s.	n.s.
SM3	44.9 b	37.2 ab	30.7 a	37.8	37.4	40.0	38.7	34.0	***	n.s.	n.s.	n.s.
SM4	60.3 c	44.5 b	25.5 a	48.4 b	38.5 a	42.8	46.6	40.9	n.s.	**	n.s.	n.s.
SM5	31.9	30.8	28.2	29.1	31.6	30.8	29.4	30.8	**	n.s.	n.s.	n.s.
SM6	28.4	32.9	31.4	29.1	32.7	32.5	30.7	29.6	**	n.s.	n.s.	n.s.

[a]numbers marked with the same letter in a particular line are not significantly different; ***, **, * probability level at 0.001; 0.01; 0.05; n.s. – non significant

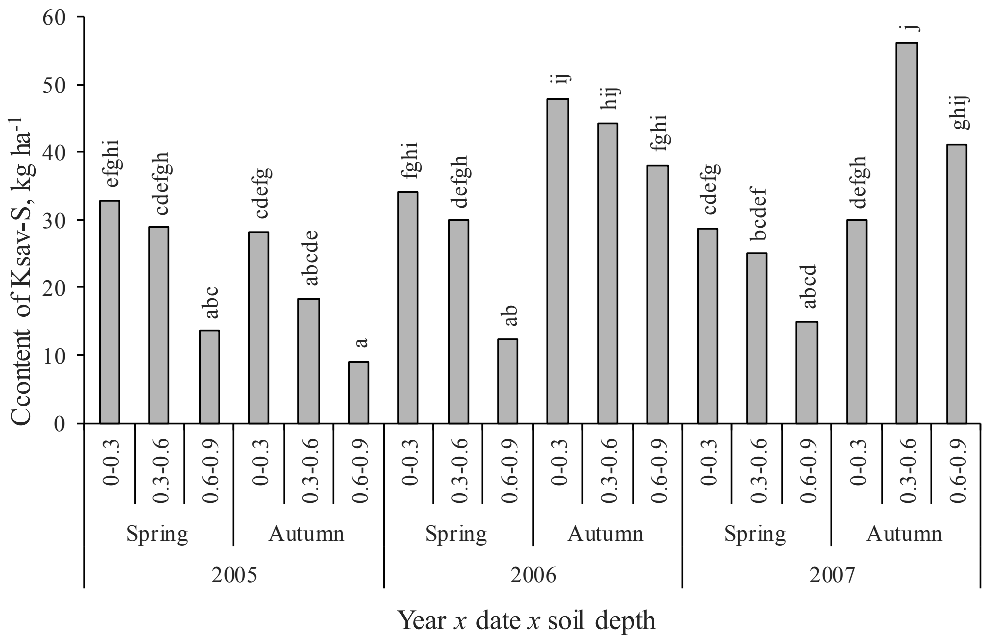
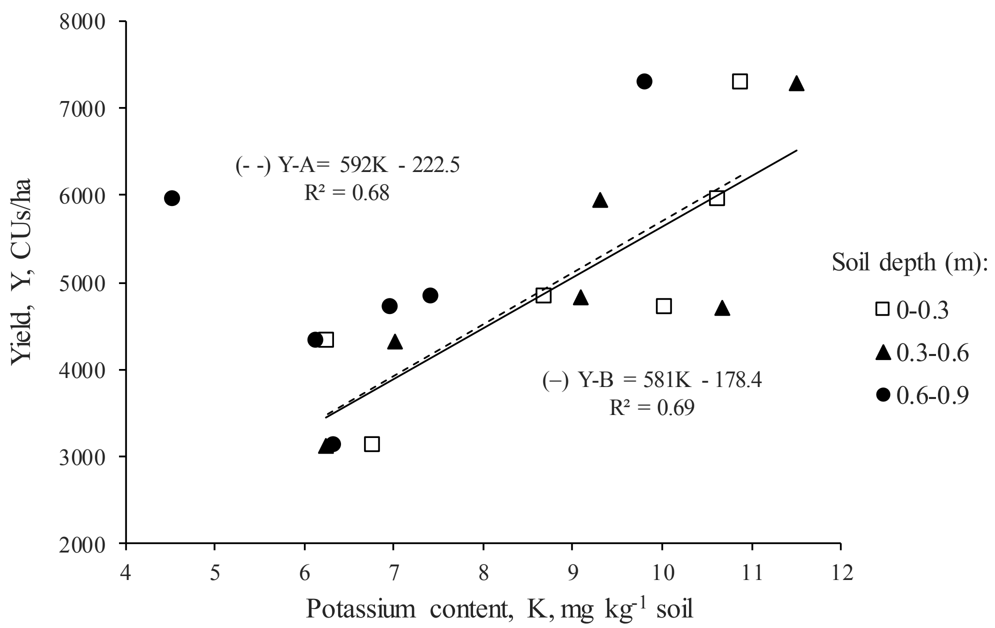


Fig. 3. The vertical distribution of soil potassium content during the season in consecutive years



Legend: A, B, C – soil layers 0–0.3, 0.3–0.6, 0.6–0.9 m

Fig. 4. Yield of maize cropping sequences in accordance to K content in soil layers

The repeated application of manure creates conditions for improvement of soil structure and contents of numerous nutrients [Sienkiewicz et al. 2009]. The study showed that maize can use these resources very effectively.

CONCLUSIONS

1. The Unit Potassium Productivity, irrespectively of the K pool, used for calculation, was a good diagnostic tool to determine differences in K management between both cropping sequences.
2. The negative values of the Total K Balance and Total Gross K Balance clearly indicate on soil available potassium as an important source for grown crops.
3. Yields of crops cultivated in both cropping sequences depended significantly on soil K resources, being, however, more pronounced for maize.
4. Maize, especially grown for silage, caused a stronger exhaustion of soil K available pool, compared to sequences with oilseed rape as a dominant crop.
5. Maize showed much higher potential to exploit K soil available resources compared to oilseed rape in turn, leading to soil potassium exhaustion.

REFERENCES

Barraclough P.P. 1989. Root growth, macro-nutrient uptake dynamics and soil fertility requirements of a high-yielding winter oilseed rape crop. Plant Soil 119: 59–70.

Brankatschk G., Finkbeiner M. 2014. Application of the Cereal Unit in a new allocation procedure for agricultural life cycle assessments. J. Cleaner Prod. 73: 72–79.

Cherry K.A., Shepherd M., Withers P.J.A., Mooney S.J. 2008. Assessing the effectiveness of actions to mitigate nutrient loss from agriculture: a review of methods. Sci. Total Environ. 406: 1–23.

Christen O., Sieling K 1995. Effect of different preceding crops and crop rotations on yield of winter oilseed rape (*Brassica napus* L). J. Agron. Crop Sci. 174: 265–271.

Grzebisz W., Diatta J. 2012. Constrains and solutions to maintain soil productivity: a case study from Central Europe. In: Soil fertility improvement and integrated nutrient management – A global perspective. Whalen J. (ed.). InTech, pp 25.

Grzebisz W., Oertli J.J. 1993. Evaluation of universal extractants for determining plant available potassium in intensively cultivated soils. Comm. Soil Sci. Plant Analysis 24: 1295–1308.

Hammer G.L., Dong Z., McLean G., Doherty A., Messina C., Schussler J., Zinselmeier C., Paszkiewicz S., Cooper M. 2009. Can changes in canopy and/or root system architecture explain historical maize yield trends in the U.S. Corn belt? Crop Sci. 49: 299–312.

Houba V.J.G., Temminghoff E.J.M., Gaikhorst G.A., van Vark W. 2000. Soil analysis procedures using 0.01 M calcium chloride as extraction reagents. Comm. Soil Sci. Plant Analysis 31: 1299–1396.

Madaras M. 2014. Effect of potassium budget on evolution of soil potassium in different crop sequences and site conditions. Agriculture/Polnohospodarstvo 60: 121–131.

Madaras M., Koubova M. 2015. Potassium availability and soil extraction tests in agricultural soils with low exchangeable content. Plant Soil Environ. 61: 234–239.

Rutkowska B., Pikuła D., Stępień W. 2014. Nitrogen use efficiency of maize and spring barley under potassium fertilization in long-term experiment. Plant Soil Environ. 60: 550–554.

Sienkiewicz S., Krzebietke S., Wojnowska T., Żarczyński P., Omilian M. 2009. Effect of long-term differentiated fertilization with farmyard manure and mineral fertilizers on the content of available forms of P, K and Mg in soil. J. Elementol. 14(4): 779–786.

Struik P., Bonciarelli F. 1997. Resource use at the cropping system level. Europ. J. Agron. 7: 133–143.
Szczepaniak W., Grzebisz W., Potarzycki J. 2014. An assessment of the effect of potassium fertilizing systems on maize nutritional status in critical stages of growth by plant analysis. J. Elementol. 19(2): 533–548.
Wei T., Zhang P., wang K., Ding R., Yang B., Nie J., Jia Z., Han Q. 2015. Effects of wheat straw incorporation on the availability of soil nutrients and enzyme activities in semiarid areas. PLoS ONE 10(4): e0120994.
Zlámalová T., Elbl J., Baroň M., Bělíková H., Lampíř L., Hlušek J., Lošák T. 2015. Using foliar applications of magnesium and potassium to improve yields and some qualitative parameters of vine grapes (*Vitis vinifera* L.). Plant Soil Environ. 61: 451–457.

R. Łukowiak, W. Grzebisz, P. Barłóg, J. Potarzycki, K. Kotnis

WPŁYW DWÓCH RÓŻNYCH GRUP SYSTEMÓW NASTĘPSTWA ROŚLIN W GOSPODARSTWIE PRODUKCYJNYM NA GOSPODARKĘ POTASEM

Synopsis. Głównym celem badań prowadzonych w latach 2004–2007 w gospodarstwie rolnym Górzno była ocena wrażliwości roślin uprawianych w 15 zmianowaniach z dominującym udziałem rzepaku (9 pól) lub z kukurydzą (6 pól) na gospodarkę potasem. Składowymi oceny gospodarki K były: i) ilość potasu dostępnego w glebie (ekstrakcja 0,01 M $CaCl_2$) w warstwie 0–0,9 m wiosną przez ruszeniem wegetacji i po zbiorze roślin, ii) ilość K zastosowana w nawozach mineralnych, iii) całkowita ilość K wprowadzona do gleby (nawóz, obornik, opady, nasiona/ziarno), iv) ilość potasu zawarta w plonie głównym i resztkach pożniwnych. Produktywność jednostkową K (UKP) określono oddzielnie dla głównych źródeł składnika. Bilans potasu wykonano metodą i) na powierzchni pola, ii) systemową, uwzględniając zasoby K dostępnego w glebie. Indeksy UKP, niezależnie od źródła K, okazały się dobrym narzędziem diagnostycznym do wydzielenia systemów następstwa roślin. Ujemne wartości indeksów TKB i TGKB wskazują na istotny udział zasobów glebowych potasu w pokryciu potrzeb pokarmowych uprawianych roślin. Plony roślin w obu grupach zmianowań zależały istotnie od zasobów potasu dostępnego w glebie. Kukurydza, zwłaszcza uprawiana na kiszonkę powodowała głębsze wyczerpanie gleby z zasobów dostępnego potasu w porównaniu do systemów z rzepakiem, jako dominującą rośliną.

Słowa kluczowe: rzepak ozimy, kukurydza, metody bilansowania, indeksy bilansu potasu

Accepted for print – Zaakceptowano do druku: 28.07.2017

For citation – Do cytowania:
Łukowiak R., Grzebisz W., Barłóg P., Potarzycki J., Kotnis K. 2017. The effect of two diverse group of cropping sequences in a production farm on potassium management. Fragm. Agron. 34(3): 76–87.